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The cause of a discrepancy in the CCIR Report 322–3 radio noise model is reported. The basis for this discrepancy results from the procedure used to prepare the measured noise data for the determination of a global numerical representation of the 1 MHz data. The development process of CCIR Report 322–3 is presented so that the cause of the error can be more fully understood. Then the cause itself of the error in the 1 MHz noise model is discussed. Next geographical, frequency dependence, and interpolation effects are reviewed. Finally, brief recommendations of a course of action for the development of an improved 1 MHz model are given.

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THE PROBABLE CAUSE OF A DISCREPANCY IN THE CCIR REPORT 322-3 RADIO NOISE MODEL

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Abstract

The cause of a discrepancy in the CCIR Report 322-3 radio noise model is reported. The basis for this discrepancy results from the procedure used to prepare the measured noise data for the determination of a global numerical representation of the 1 Mhz data. The development process of CCIR Report 322-3 is presented so that the cause of the error can be more fully understood. Then the cause itself of the error in the 1 Mhz noise model is discussed. Next geographical, frequency dependence, and interpolation effects are reviewed. Finally, brief recommendations of a course of action for the development of an improved 1 Mhz model are given.

Introduction

Recently, Bowen and Fraser-Smith (1992) made a comparison of measured 32 Khz radio noise amplitudes with the CCIR Report 322-3 (1988) noise model predictions. They found that the greatest discrepancies between the measured and predicted amplitudes were observed at the two northern high latitude stations (Søndre Strømfjord and Thule, Greenland), where on some occasions the predicted values were nearly five times greater than the measured values. There was moderately good agreement between the measured and predicted values at a southern high latitude site (Arrival Heights, Antarctica). The best agreement was observed at middle to low latitudes. The data used to make these comparisons were measured by a ELF/VLF measurement system (Fraser-Smith et al., 1987).

CCIR Report 322-3 is an output document of the CCIR XVIth Plenary Assembly held in Dubrovnik, Yugoslavia in 1986. It was produced by the International Working Party (IWP) 6/2 of CCIR Study Group 6 using the work of Spaulding and Washburn (1985).

Because of the wide acceptance of the CCIR Report 322-3 radio noise model, an attempt was made to determine the cause of this discrepancy. This error resulted from the procedure used to prepare the measured noise data for the determination of a global numerical representation of the 1 Mhz data. Since the contour plots of the 1 Mhz radio noise in CCIR Report 322-3 were in turn generated from the numerical representation thus developed, they are also in error.

The Process Used To Develop The CCIR Report 322-3 Radio Noise Model

CCIR Report 322 (1964) was developed using data available through October 1961. Data from the original worldwide network of recording stations continued to be measured through 1966. Many years of data from 10 Soviet measurement locations became available along with data from Thailand for March 1966 through February 1968 (Chindahporn and Younker, 1968). All of this data was analyzed and updated set of atmospheric radio noise estimates produced, essentially in the CCIR Report 322 format (Spaulding and Washburn, 1985).

The discussion here of the development of the new CCIR Report 322-3 radio noise model is based on the work of Spaulding and Washburn (1985).

The New Data

The original worldwide network locations and new locations are given in Table 1 (Table 1 in Spaulding and Washburn (1985)).

In the development of the new noise model, data from Thule, Greenland and Byrd Station, Antarctica were not used. This data was not used because it was assumed that it was generally contaminated by high levels of man-made noise.

For a number of years the Soviet Union operated a network of ten noise measurement stations. Raw data were available on microfilm from the World Data Center (National Oceanic and Atmospheric Administration, Boulder, CO 80303) for periods of time from mid-1958 through 1965, coincident with the measurements of the worldwide network. The parameters that were measured were different from those discussed for the worldwide network above. The conversion of these parameters to parameters equivalent to that of the worldwide network are discussed by Spaulding and Washburn (1985). The measurement frequencies and other information for each of the Soviet measurement locations are also summarized in Spaulding and Washburn (1985).

Table 1. Atmospheric noise measurement locations

WORLDWIDE NETWORK LOCATIONS (CCIR 322)		
Balboa, Canal Zone	79.5W	9.0N
Bill, Wyoming	105:2W	43.2N
Boulder, Colorado	105.1W	40.1N
Byrd Station, Antarctica	120.W	80.0S
Cook, Australia	130.4E	30.6S
Enkoping, Sweden	17.3E	59.5N
Front Royal, Virginia	78.2W	38.8N
Ibadan, Nigeria	3.9E	7.4N
Kekaha, Hawaii	159.7W	22.0N
New Delhi, India	77.3E	28.8N
Ohira, Japan	140.5E	35.6N
Pretoria, South Africa	28.3E	25.8S
Rabat, Morocco	6.8W	33.9N
San Jose, Brazil	45.8W	23.3S
Singapore	103.8E	1.3N
Thule, Greenland	68.7W	76.6N

NEW LOCATIONS		
Alma Ata, USSR	76.92E	43.25N
Ashkhabad, USSR	58.3E	37.92N
Irkutsk, USSR	104.5E	52.0N
Khabarovsk, USSR	135.0E	50.0N
Kiev, USSR	30.3E	50.72N
Laem Chabang,	100.9E	13.05N
Moscow, USSR	37.32E	55.47N
Murmansk, USSR	35.0E	69.0N
Simferopol, USSR	34.03E	45.02N
Sverdlovsk, USSR	61.07E	56.73N
Tbilisi, USSR	40.0E	41.72N

Analysis of the Soviet Data

The analysis involved determining, at each frequency, for each 3-month period and 4-hour time block, the median value of all the data. These median values at the various frequencies were then used to determine the approximate 1 Mhz F_{am} value. This value was then used to obtain a correction value to the CCIR Report 322 value. Figure 1 (Figure 8 in Spaulding and Washburn (1985)) shows an example for Moscow for June, July, August (Northern Hemisphere Summer) and 1600-2000 hours. Note that the noise curve for a quiet receiving location falls considerably below the analyzed median values. A computer algorithm was developed that determined the atmospheric noise frequency variation curve that "best" fit the data. However, since the median value at some frequencies was based on much more data than the value of the other frequencies for a location, time block, and season (due to missing data and some frequencies being stressed at some locations); this "fitting" process was generally done by hand (visually). On Figure 1, the "best" fitting frequency law curve was determined to be 72 Db. The CCIR Report 322 value is 65 dB. Hence, a value of +7 dB can be used to correct the atmospheric noise predicted by CCIR Report 322 at Moscow during the summer at 1600-2000 hours. Figure 2 (Figure 9 in Spaulding and Washburn (1985)) shows an example for Moscow for the period November, December, January, 0800-1200 hours. Atmospheric noise would be expected to be low during this period (winter morning) and could possibly be contaminated by man-made noise at the higher frequencies. For the higher frequencies 350 kHz and above, the Figure shows a typical man-made noise curve at a level to be expected for a quiet receiving site. Because of this contamination possibility, the lower frequencies were used to determine the frequency law curve. In this cast the frequency law curve for 31 dB was determined. The CCIR Report 322 value was 29 dB, resulting in a required correction of +2 dB.

Corrections to CCIR Report 322 1 MHz Values

The procedure illustrated above for Figures 1 and 2 for determining the corrections to be made to CCIR Report 322 was followed by Spaulding and Washburn (1985) to obtain corrections for each location and for each 3-month/4-hour time block. Tables 2 gives the corrections determined using this procedure for the December, January, February season. Similar tables for the other three seasons are given in Spaulding and Washburn (1985). The table contains a correction for time block and for each station in Table 1 except for those noted below. The "correction" is the difference between the CCIR Report 322 1 MHz F_{am} value and the corresponding value determined using the above procedure from the data.

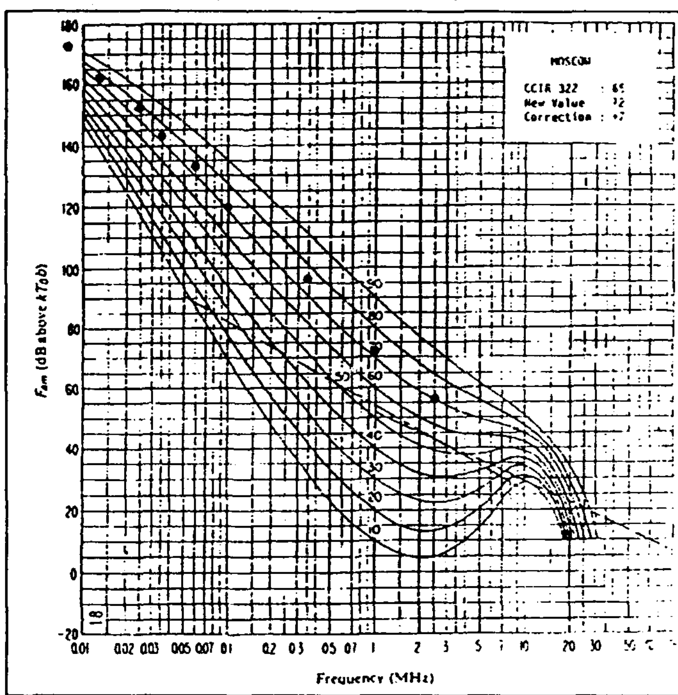

Figure 1. Determination of 1 MHz F_{am} value for Moscow, June, July, August, 1600-2000 hours (Spaulding and Washburn, 1985)

For certain stations listed in Table 1, no corrections were determined. No correction values were obtained for Thule, Greenland and Byrd Station, Antarctica because it was assumed that the data was contaminated by man-made noise. Since there were no data from Ibadan, Nigeria past the data used in the development of CCIR Report 322; no correction was used for Ibadan. Because the corrections for Bill, Wyoming and Boulder, Colorado were essentially identical, only corrections for Boulder were used. Corrections were used for only 6 Soviet locations rather than 10. Simferopol, Sverdlovsk, Tbilisi, and Kiev either had only small amounts of usable low frequency data necessary to determine the proper 1 MHz F_{am} value or were close to other measurement locations. The data at these four Soviet locations were analyzed to ascertain that the corrections agreed with those used at nearby locations, namely Moscow and Ashkhabad. For Murmansk; for the March, April, May season; and for the four time blocks 0400-0800, 0800-1200, 1200-1600, and 1600-2000 hours, the data were highly irregular and confusing. Hence, Spaulding and Washburn (1985) decided not to attempt to obtain any correction values for Murmansk for these four periods.

Because the original contour maps in CCIR Report 322 were produced directly from a grid of equally spaced 84 longitude by 100 latitude points for each time block/season, the next step in the analysis was to translate the correction data for the nineteen sites to this same 84 by 100 lattice. Then data for new noise model was found simply by adding the corrections point-by-point for the grid point of original data.

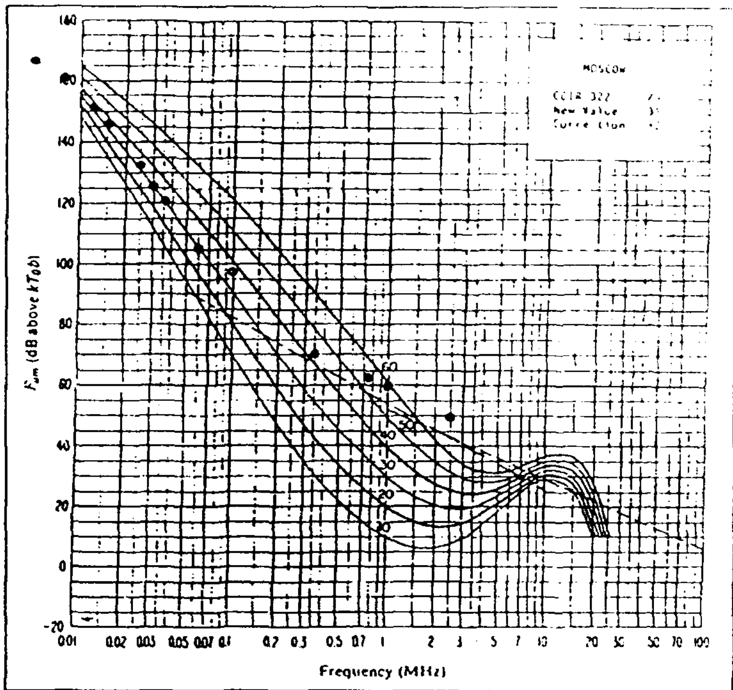

Figure 2. Determination of 1 MHz F_{am} value for Moscow, December, January, February, 1000-1200 hours (Spaulding and Washburn, 1985)

To do this Spaulding and Washburn (1985) utilized an interpolation method due to Dr. Charles L. Lawson (1982, 1984) for interpolating scattered data over a sphere. This method first constructs a triangular grid over a surface (in this case the Earth) using a given set of points as vertices (in this case the 19 data points in Tables 2 and Tables 3 through 5 in Spaulding and Washburn (1985)). Then continuous first partial derivatives are estimated by the method at each vertex using local quadratic least squares approximations to given data values at nearby vertices. The method for interpolation then uses six Hermite cubic interpolations along arcs of great circles. Figure 3 is an example of the resultant contour maps of the 24 (four 3-month periods, six 4-hour time blocks) 100 by 84 correction grids produced by Spaulding and Washburn for December, January, February for 12001600 hours (The other 23 maps can be found in Spaulding and Washburn (1985) as Tables 10 to 12 and as Tables 14 to 33). These maps show the changes to the CCIR Report 322 to be made. There are substantial corrections in some areas as could also be seen by examining Tables 2 and Tables 3 through 5 in Spaulding and Washburn (1985). The correction maps are presented in terms of three-month periods rather than as season (which results in a discontinuity at the equator) as in CCIR Report 322.

The New 1 MHz F_{am} Values

The new 1 MHz F_{am} data values for constructing a new 1 MHz noise model where obtained by Spaulding and Washburn (1985) by adding each of the 84 longitude by 100 latitude grid of correction values to the corresponding original 84 longitude by 100 latitude grid data values from which CCIR Report 322 was constructed.

In developing a numerical representation for these new 1 MHz F_{am} maps, Spaulding and Washburn used the method used by Lucas and Harper (1965). Spaulding and Washburn give details on how these coefficients were obtained.

These numerical maps represent a "smoothed" version of the original data and are the new 1 MHz F_{am} worldwide atmospheric noise estimates. Figures 34-57 in Spaulding and Washburn (1985)) are contour plots of these estimates. Upon comparing the numerical representation thus obtained for each of the 8400 original data points (84 x 100 grids) for each of the 24 numerical maps, Spaulding and Washburn found an rms variation that ranged from 0.88 dB to 2.37 dB over the 24 maps with an average rms variation of 1.52 dB and with a maximum deviation of 6.7 dB (all maps considered, i.e., 24 x 8400 points). The contour plots in CCIR Report 322-3 are similar, except the CCIR IWP 6/2 gathered the plots together by season rather than by months. This resulted in the discontinuity at the equator shown in CCIR Report 322-3.

The Probable Source of the Error in the CCIR Radio Noise Model

The probable source of the error in the CCIR radio noise model is most likely due to the non-use of correction factors for Thule, Greenland; Byrd Station, Antarctica; Ibadan, Nigeria; and Bill, Wyoming. In the case of Thule and Byrd Station, data from these sites were used in the original CCIR noise model. One would anticipate that if the data were contaminated by man-made noise that a negative correction factor would be the likely case. Thus, it would seem desirable to determine correction factors for these sites as was done for the other sites. That is, the data at lower frequencies could have been used to obtain correction factors at 1 MHz.

Certainly, there is evidence that the measurements at Thule at 2.5 and 5.0 MHz were contaminated by man-made noise (Herman, 1962). However, Herman (1963) showed that Byrd Station is an exceptionally quiet location and would be a good site for making a variety of radio measurements requiring a low noise background. At Thule man-made noise on 2.5 and 5.0 MHz appeared to be 57 and 49 dB above kTB, respectively, while at Byrd Station the values were about 20 and 12 dB, respectively (Herman, 1964). These values were estimated from data taken during a PCA, when atmospheric noise was absent. The corresponding values for a quiet rural site at 2.5 and 5.0 MHz are 43 and 34 dB, respectively. Both sites are affected by galactic noise at 10.0 and 20.0 MHz. In the case of Ibadan, no addition data was available beyond the last date for data used in the original CCIR 322 noise model. Not even a correction factor of zero was used to maintain the status quo was used for these three sites. In the case of Bill, data was not included because the correction factors obtained for it nearly the same as for Boulder, Colorado, which was in close proximity to Bill, Wyoming.

Table 2. Corrections (dB) to CCIR Report 322 1 MHz F_{am} values for December, January, and February (Spaulding and Washburn (1985))

PLACE	LOCATION	LOCAL TIME					
		00-04	04-08	08-12	12-16	16-20	20-24
Alma Ata	76.9E, 43.2N	-7	-6	6	5	-3	-6
Irkutsk	104.5E, 52.0N	-21	-25	-7	-15	-25	-25
Khabarovsk	135.0E, 50.0N	-19	-15	-8	-7	-20	-20
New Delhi	77.3E, 28.8N	-13	7	17	17	8	11
Ohira	140.5E, 35.6N	7	7	8	12	11	11
Thailand	100.9E, 13.0N	14	15	24	18	17	15
Singapore	103.8E, 1.3N	0	6	12	9	5	1
Kekaha	159.7W, 22.0N	5	10	8	15	5	5
Boulder	105.1W, 40.1N	5	4	7	14	7	8
Front Royal	78.2W, 38.8N	-1	2	3	8	0	0
Balboa	79.5W, 9.0N	3	6	7	9	7	2
Rabat	6.8W, 33.9N	2	4	3	8	2	4
Enkoping	17.3E, 59.5N	12	10	-1	8	7	7
Murmansk	35.0E, 69.0N	8	5	7	9	7	7
Moscow	37.3E, 55.5N	4	3	2	4	0	-1
Ashkabad	58.3E, 37.9N	-9	-1	-5	-5	-6	-12
Cook	130.4E, 30.6S	2	-3	6	1	6	3
San Jose	45.8W, 23.3S	2	0	2	2	4	3
Pretoria	28.3E, 25.8S	-4	8	-4	1	5	-8

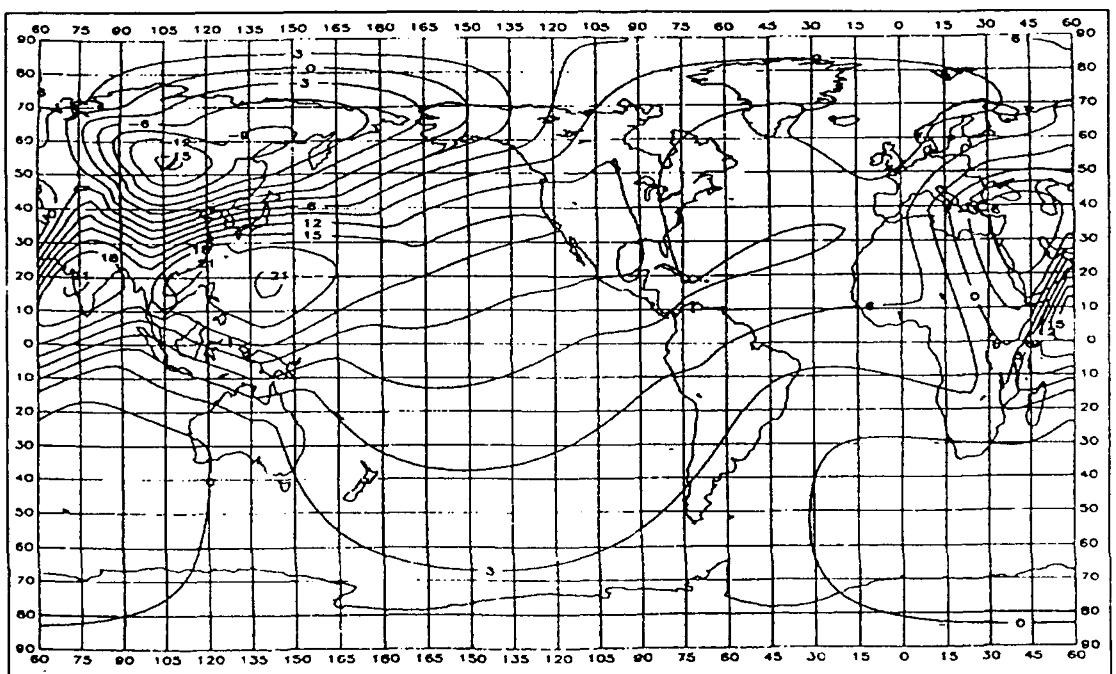

Figure 3. Corrections (dB) to original CCIR Report 322 1 MHz F_{am} estimates, December, January, February, 1200-1600 hours (Spaulding and Washburn, 1985)

The net result of not including correction factors (not even zero to maintain the status quo) for these four locations was that the interpolation algorithm used to determine the 100 latitude by 84 longitude data points supplied erroneous correction factors at these sites. Tables 3 through 6 give the error in the correction factor for these four sites. For Thule, Byrd Station, and Ibadan, the error is the difference between the correction factors given in Figures 10 through 33 in Spaulding and Washburn and zero for the status quo. For Bill the error is the difference between those given in these figures and the correction factor input for Boulder, Colorado. It was anticipated that the errors at Thule and Byrd station might be large, but it was a surprise see the magnitude of the errors at Ibadan. For Thule the maximum and minimum errors in the correction contours from zero status quo were 10.1 and -10.8 dB, respectively. For Ibadan the maximum and minimum errors were 12.5 and -1.5 dB, respectively. For Byrd Station the maximum and minimum errors were 12.0 and 3 dB, respectively. The error for Bill, Wyoming is within the rms error of the numerical maps of CCIR Report 322 3.

Table 3. Interpolation errors (dB) for select measurement locations for December, January, February

LOCATION NAME	LOCAL TIME					
	00-04	04-08	08-12	12-16	16-20	20-24
Thule	7.0	3.5	6.0	6.0	3.0	6.0
Ibadan	-0.4	6.0	0.6	5.5	3.0	-1.5
Bill	-0.8	-0.6	-1.0	-0.3	-1.0	-1.0
Byrd Station	3.0	0.0	5.5	2.0	6.0	5.5

Table 4. Interpolation errors (dB) for select measurement locations for March, April, and May

LOCATION NAME	LOCAL TIME					
	00-04	04-08	08-12	12-16	16-20	20-24
Thule	3.0	-3.0	-3.0	-4.1	-10.8	3.0
Ibadan	3.0	3.0	8.2	0.8	5.0	0.0
Bill	-1.0	-0.9	-1.0	-0.5	-1.0	-0.6
Byrd Station	4.0	8.0	12.0	7.3	10.2	7.0

Table 5. Interpolation errors (dB) for select measurement locations for June, July, and August

LOCATION NAME	LOCAL TIME					
	00-04	04-08	08-12	12-16	16-20	20-24
Thule	-1.3	6.0	1.5	6.0	10.1	0.0
Ibadan	5.3	7.4	10.6	0.0	4.5	8.0
Bill	-0.5	-1.0	-1.0	-1.0	-1.0	-0.7
Byrd Station	8.3	8.0	12.0	7.3	10.2	7.0

Table 6. Interpolation errors (dB) for select measurement locations for September, October, November

LOCATION NAME	LOCAL TIME					
	00-04	04-08	08-12	12-16	16-20	20-24
Thule	-6.0	3.0	0.0	3.0	3.0	-2.5
Ibadan	5.5	10.7	12.5	5.2	8.8	5.3
Bill	-1.4	-1.0	-1.0	-1.0	-0.7	-0.6
Byrd Station	3.0	4.9	12.0	9.0	3.0	3.0

Geographical Effects

To see the geographical effect of these errors, contour plots were made of the errors for each time block and season. For the 19 locations used to determine the correction factor contours in Figures 10 through 33 in Spaulding and Washburn (1985), the error was assumed to be zero. It was assumed that the interpolation process gave the same values for the correction factors at these sites as was input. The values given in Tables 3 through 6 were used for the other four sites. The graphics program Axum was used to plot the errors for the irregularly spaced data points. Axum rarely was able to determine a grid spacing greater than fifty by fifty for its internal interpolation for the contour plotting. Examples of the results of Sailors (1993) are presented in Figures 4 through 7. Note that the longitudes are positive for degrees East of Greenwich (zero degree) and negative for degrees West of zero degree. Positive latitudes are Northern latitudes, and negative latitudes are Southern latitudes. The locations of the four sites for which no correction factors were used in the interpolation are approximately given in the figures. Examination of these figures reveals that the geographical extent of the error is not confined to the measurement location but in fact in some cases is very large. This is especially true in the Northern and Southern high latitudes, the Arabian Peninsula, Northern Africa, and the Mid-Atlantic areas. Note that the geographical extent of the error is both seasonally and diurnally dependent.

Frequency Dependence Effects

As the CCIR Report 322-3 atmospheric noise model can be used at frequencies from 10 kHz through 30 MHz, it is important to be able to translate an error in the 1 MHz model to an error at any frequency in this frequency range. To determine this relationship, the frequency dependence model was used, assuming no error inherit in it. This model obtains the noise at any frequency by putting in the 1 MHz value for a particular time block and season into a set of curves parametric in the 1 MHz value. For each time block and seasons, there is a range of possible input 1 MHz values for which the atmospheric noise can be obtained depending on the location of the receive site. To obtain the error at an arbitrary frequency, time block, and season; each of the parametric values were perturbed by 10 and -10 dB errors and the resultant errors, respectively, were determined. The statistical average, high and low values were then obtained. It was found that the error at each of the 35 frequencies from 10 kHz through 30 MHz used did not depend significantly on the parametric curve value. However, the error was diurnally dependent. The maximum errors for each frequency occurred during the local time daytime, and the minimum error errors occurred during the nighttime. Figure 8 shows the average, high, and low error as a function of frequency and 1 MHz error. The figure shows the error for -10 dB to be a mirror image of that for a 10 dB error.

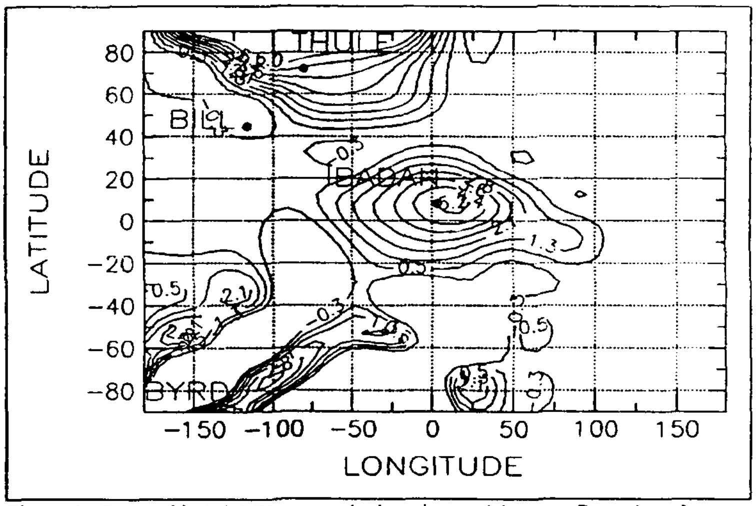

Figure 4. Geographical 1 MHz atmospheric noise model error, December, January, February, 1200-1600 hours

Interpolation Effects

The accuracy of the interpolation itself is affected by the lack of inclusion of data from the four measurement locations. First, the number of triangles and number of edges of these triangles is reduced. Lawson (1977) gives equations for both the number of triangles n_t and number of edges n_e as a function the number distinct points n in the set S, the number of points n_b in S on the boundary of the convex hull of S, and the number of points n_i in the interior of the convex hull of S so that $n = n_b + n_i$. In the case of data points on a sphere, $n_b = 0$ (i.e., there are no boundary points). For $n = 19$, $n_t = 36$ and $n_e = 54$. For $n = 23$, $n_t = 44$ and $n_e = 66$. Thus there is an 122.22 percent increase in triangle edges by adding the four points. Second, the number of input data points affects how the C^1 surface interpolation determines the triangles themselves. Each pair of triangles forms a quadrilateral. The Lawson criterion requires that the smallest of the six angles in the two triangles of a quadrilateral should be larger for this division of a convex quadrilateral than that given by the other diagonal (Ripley, 1981). Thus when the four data measurement locations were not used in the model development, the triangulation was considerably changed and may not have been optimum. Further, Akima (1984) has shown that poor estimates of partial derivatives usually occurs when a thin (or slim) triangle is involved in the interpolation, which affects the accuracy of the interpolation. This case was more likely to have occurred when the four data locations, particularly the two high latitude sites, were left out.

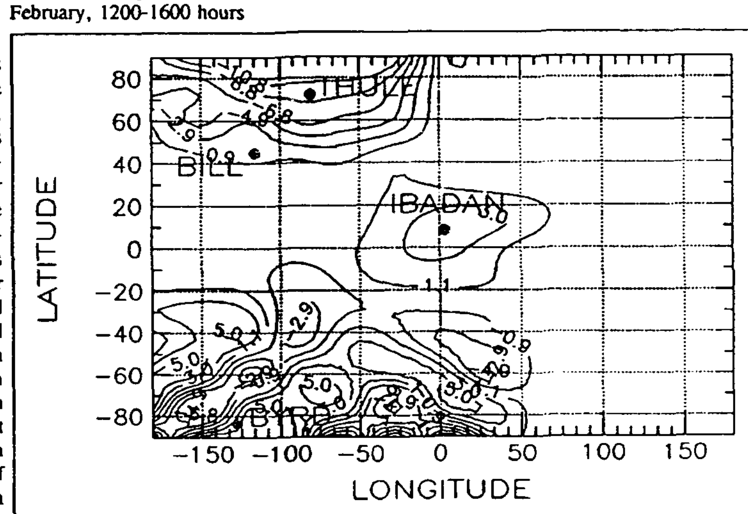

Figure 5. Geographical 1 MHz atmospheric noise model error, March, April, May, 1600-2000 hours

Several of the contour plots giving the correction factors in Spaulding and Washburn's Figures 10 through 33 have values larger or smaller than the extreme values used in the interpolation to obtain these figures. The figures with the minimum extreme less than the input minimum extreme usually had this extreme occurring at one or two of the same locations. These two locations were either in the very most Eastern part of Asia or in the North Atlantic just south of Greenland. These last two extremes likely would not have occurred had the data at Thule, Greenland been used; in this case the triangulation would have been considerably different. The figures with the maximum extreme greater than input maximum extreme usually had this extreme occurring at one or two of the same locations. The first location was usually in the vicinity of Guam. An example is shown in Figure 3 above. The second location was in the South Atlantic between South America and Africa. This latter location would not have been affected by the triangulation if the data from Ibadan, Nigeria and Byrd Station, Antarctica had been included. However, the extreme occurring in the vicinity of Guam is due the gradients occurring in the input data in Eastern Asia. The data there goes from large negative corrections in the North to Large positive corrections at Singapore. The interpolation program extrapolated to obtain the large positive correction factors in the vicinity of Guam. Further, in this case the triangulation would not have changed if the data for the other four locations had been included in the model development. Whether this correction is valid or not is unclear. Addition input data in the vicinity of Guam would have been useful.

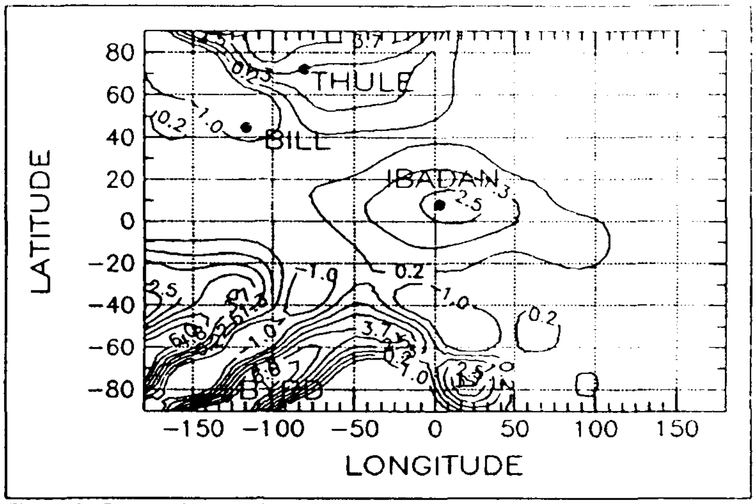

Figure 6. Geographical 1 MHz atmospheric noise model error, December,January, February, 1600-2000 hours

Conclusions and Recommendations

This paper has presented the probable cause for a discrepancy in the CCIR Report 322-3 radio noise model. This report has not determined whether there is a discrepancy between the new CCIR model and the data values used to develop it. Nor has there been an attempt to determine the validity of the measured data values used to develop the model or to validate the model against any other data.

The basis for this discrepancy was found to be in the procedure used to prepare the measured noise data for the determination of a global numerical representation of the 1 MHz data. The procedure followed in the development of the model was to determine correction factors to the old CCIR model for each measurement site, to interpolate these corrections to a 100 latitude by 84 longitude grid for each time block/season, to add the correction factors at each grid point to corresponding values for the old CCIR model, and finally to numerically map the resulting data for each time block and season. Nineteen locations were used in the final model. Four sites used in the original CCIR model were not used. These include Bill, Wyoming; Byrd Station, Antarctica; Ibadan, Nigeria; and Thule, Greenland. As no correction factors were obtained for these locations or a correction factor of zero used, the interpolation algorithm used to obtain the 100 latitude by 84 longitude grid of correction factors supplied erroneous values. For Bill, Wyoming the result is not too serious; but for the other three sites, the error is at some seasons and time of day serious. For Thule, Greenland the maximum and minimum errors in the correction contours were 10.1 and -10.8 dB, respectively. For Ibadan, Nigeria the maximum and minimum errors were 12.5 and -1.5 dB, respectively. For Byrd Station, Antarctica the maximum and minimum errors were 12.0 and 3.0 dB, respectively. Examination of the geographical extent of these errors reveals that the error is not confined to the measurement location but in fact is very large. It was found that the error as a function of frequency was diurnally dependent. An error of 10 dB at 1 MHz was more serious at another frequency during local daytime than at night. Finally, the absence of the data locations affected the accuracy of the interpolation itself.

Because of the errors in the CCIR Report 322-3 atmospheric noise model, it is recommended that it be used with caution. It is most accurate in Europe, Asia, the Indian Ocean, the Western Pacific from Asia to the date line, and Australia. It is most inaccurate in both the Northern and Southern high latitudes, the Arabian Peninsula, Northern Africa, and the Mid-Atlantic Ocean area. For applications in latter list of areas, the user should consider using the original CCIR Report 322 model.

A three step process should be followed to develop a new 1 MHz atmospheric noise model. First, obtain correction factors for additional locations to increase the accuracy of the interpolation. Second, test the method of interpolation against a bench mark. Third, use the Zacharisen and Jones (1970) numerical mapping technique applied in local time to develop the final model. Consider using a latitude transformation to increase the accuracy of the numerical mapping technique.

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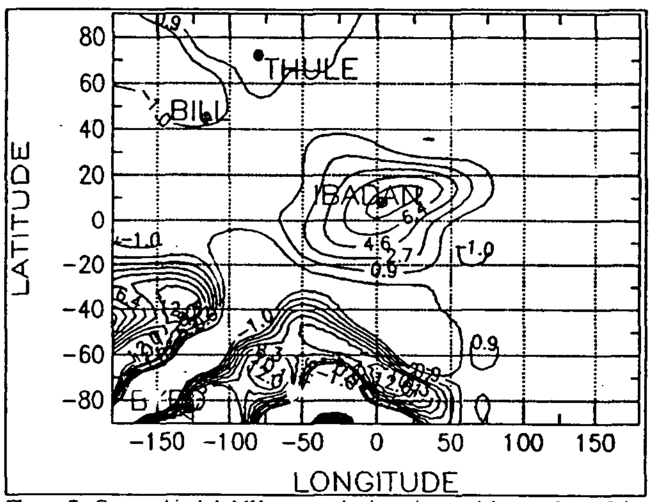

Figure 7. Geographical 1 MHz atmospheric noise model error,June, July, August, 0800-1200 hours

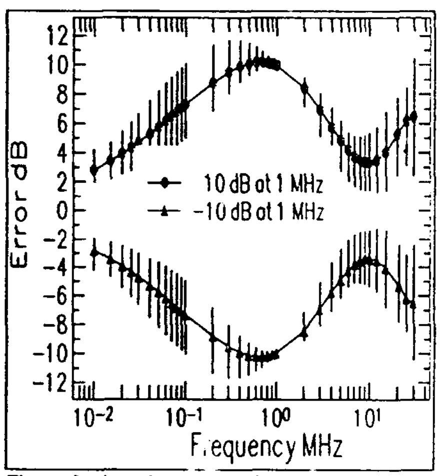

Figure 8. Error in atmospheric noise as a function of frequency for a given error at 1 MHz. mean, maximum, minimum for all time blocks